



National Transportation Safety Board

Washington, D.C. 20594

Safety Recommendation

Date:

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In reply refer to: M-97-14 and -15

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On June 10, 1995, the Panamanian passenger ship *Royal Majesty* grounded on Rose and Crown Shoal about 10 miles east of Nantucket Island, Massachusetts, and about 17 miles from where the watch officers thought the vessel was. The vessel, with 1,509 persons on board, was en route from St. George's, Bermuda, to Boston, Massachusetts. There were no deaths or injuries as a result of this accident. Damage to the vessel and lost revenue, however, were estimated at about \$7 million.¹

The National Transportation Safety Board determines that the probable cause of the grounding of the *Royal Majesty* was the watch officers' overreliance on the automated features of the integrated bridge system, Majesty Cruise Line's failure to ensure that its officers were adequately trained in the automated features of the integrated bridge system and in the implications of this automation for bridge resource management, the deficiencies in the design and implementation of the integrated bridge system and in the procedures for its operation, and the second officer's failure to take corrective action after several cues indicated the vessel was off course.

Contributing factors were the inadequacy of international training standards for watchstanders aboard vessels equipped with electronic navigation systems and integrated bridge systems and the inadequacy of international standards for the design, installation, and testing of integrated bridge systems aboard vessels.

The performance of the watch officers during the voyage and the circumstances leading to the grounding were linked to several error-inducing deficiencies in the design of the integrated bridge system and to an inefficient layout of system displays on the bridge. For example, although the National Marine Electronics Association (NMEA) 0183 output data from the 920 global positioning system (GPS) receiver should have been programmed to identify the receiver

¹ For more information, read Marine Accident Report—*Grounding of the Panamanian Passenger Ship Royal Majesty on Rose and Crown Shoal near Nantucket, Massachusetts, June 10, 1995* (NTSB/MAR-97/01).

as an integrated instrument (II) talker with a system mode (*SYS*) sentence to indicate GPS or dead-reckoning (DR) mode, the industry standard NMEA 0183 data protocol did not provide a *SYS* identifier for the DR mode. In short, the NMEA did not consider that hybrid mode receivers could use DR as one of their modes of determining position. Consequently, the Raytheon designers chose to use the GPS *GP* identifier in the NMEA 0183 output, regardless of whether the 920 GPS device was transmitting valid GPS data or DR-derived position data.

To account for this, however, Raytheon also programmed the 920 GPS to automatically set the NMEA 0183 *valid/invalid* position data bits to the *invalid* state when the GPS was operating in the solution (SOL) and/or DR mode. In doing so, Raytheon assumed that a listener device, such as the navigation and command system (NACOS) 25, using position data from a GP talker would recognize when the data were flagged *invalid*.

Once the desired position receiver was selected by the *Royal Majesty's* crew, the NACOS 25 took position data from the chosen position receiver based on the *talker* identifier code in the NMEA 0183 data stream; in this case, *GP* in the data stream from the Raytheon 920 GPS. STN Atlas, the manufacturer of the NACOS 25, did not expect a device identifying itself as *GP* to send position data based on anything other than GPS data, particularly not on DR-derived position data. Further, STN Atlas expected inaccurate or failed GPS position data to be recognizable by nulled position data fields or by no change in the position latitude/longitude, the latter of which would trigger the NACOS 25 position-fix alarm. STN Atlas therefore chose not to program the NACOS 25 to check the *valid/invalid* bits in the NMEA 0183 data stream as a means of detecting invalid GPS data. Consequently, when the GPS defaulted to the DR mode, the NACOS 25 was unable to recognize the status change; and thus its subsequent navigation did not correct for the effect of wind, current, or sea. The Safety Board concludes that because the industry standard NMEA 0183 data protocol did not provide a documented or standardized means of communicating or recognizing that a DR positioning mode was in use by a hybrid, DR-capable position receiver, Raytheon and STN Atlas adopted different design philosophies about the communication of position receiver mode changes for the 920 GPS and the NACOS 25.

Nevertheless, STN Atlas was aware of and claimed compatibility with the NMEA 0183 protocol containing the *valid/invalid* status bits used by Raytheon and was capable of making the NACOS 25 NMEA 0183 interface fully compatible with those specifications if it wanted to do so (including the recommended minimum GPS data sentence *RMC*). Therefore, the Safety Board further concludes that STN Atlas should have, in order to help ensure safety and compatibility with different NMEA 0183 position receivers, programmed the *Royal Majesty's* NACOS 25 to recognize the *valid/invalid* status bits in the NMEA 0183 data, including those specified in the NMEA 0183 v1.5 *RMC* recommended minimum GPS data sentence. The Safety Board is aware that since the accident, STN Atlas has taken steps to program its integrated navigation system NMEA 0183 interfaces to meet a newer, more comprehensive NMEA 0183 version and to ensure that no DR-capable position receivers are used with its NACOS integrated navigation system. The Safety Board believes that Raytheon should design its hybrid positioning systems to identify themselves as integrated instruments (II) with an appropriate system mode identifier (*SYS*) in coordination with the NMEA.

The design of the integrated bridge system consolidated most of the officers' watchstanding navigation activities at the central console when the *Royal Majesty* was underway. Therefore, of particular concern was the alarm system for the GPS. The internal aural alarm for the GPS lasted 1 second, despite its critical function. Neither the brief aural alarm nor the visual alarm, in the form of very small *DR* and *SOL* on the GPS receiver's screen, could be easily seen or heard at the command console. Rather, the GPS receiver was in the chart room behind the console on the bridge. The remoteness of the location probably precluded the *Royal Majesty's* watch officers' hearing the GPS receiver's brief aural alarm or initially noticing the *DR* and *SOL* indications when the GPS defaulted to the DR mode. Further, the integrated bridge system installer did not connect the GPS receiver's external alarm switch to a loud and continuous external alarm, even though one was available. Had the GPS external alarm been installed or had its internal aural alarm required user action to silence it, the officers would have been alerted to the GPS antenna problem shortly after leaving St. George's. Consequently, the Safety Board concludes that the Raytheon 920 GPS receiver's brief aural alarm, the remoteness of the receiver's location, and the failure of the installer to connect the GPS external alarm resulted in the inadequacy of the aural warning sent to the crew when the GPS defaulted to the DR mode. In view of the foregoing, the Safety Board believes that Raytheon should design its position receivers to provide continuous aural alarms that require positive user action to silence them.

Therefore, the National Transportation Safety Board recommends that Raytheon Marine:

Design its hybrid positioning systems to identify themselves as integrated instruments (II) with an appropriate system mode identifier (*SYS*). (M-97-14)

Design its position receivers to provide continuous aural alarms that require the user to take action to silence them. (M-97-15)

The Safety Board also issued Safety Recommendations M-97-1 through -4 to Majesty Cruise Line; M-97-5 through -11 to the U.S. Coast Guard; M-97-12 and -13 to STN Atlas Elektronik GmbH; M-97-16 through -18 to the National Marine Electronics Association; M-97-19 and -20 to the International Electrotechnical Commission; M-97-21 through -26 to the International Council of Cruise Lines; and M-97-27 and -28 to the International Chamber of Shipping and to the International Association of Independent Tanker Owners. The Safety Board also reiterated Safety Recommendations M-93-18 and -19 to the U.S. Coast Guard.

The National Transportation Safety Board is an independent Federal agency with the statutory responsibility "to promote transportation safety by conducting independent accident investigations and by formulating safety improvement recommendations" (Public Law 93-633). The Safety Board is interested in any action taken as a result of its safety recommendations. Therefore, it would appreciate a response from you regarding action taken or contemplated with respect to the recommendations in this letter. Please refer to Safety Recommendations M-97-14 and -15. If you need additional information, you may call (202) 314-6450.

Chairman HALL, Vice Chairman FRANCIS, and Members HAMMERSCHMIDI, GOGLIA, and BLACK concurred in these recommendations.

By: 
Jim Hall
Chairman